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EXPERIMENTAL RESEARCH ON THE BEHAVIORAL BLOCKING OF FILTER VENTS ON LOW-YIELD CIGARETTES

A Thesis in

Biobehavioral Health

by

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Chapter 5

VENT BLOCKING DETECTION: STUDY 3

Introduction

The purpose of Study 3 was to evaluate the reliability and validity of a more precise means of rating tar stains for evidence of vent blocking.

Method

Cigarettes

The same 202 cigarette butts as used in Study 2 were rated in Study 3. (See Table 4 in Chapter Four for a description of these cigarettes.)

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Scoring Procedure

Rather than using fixed criteria to score stain patterns as in the previous two studies, the raters were asked to estimate the proportion of the filter with tar stain reaching to the outside edge. To simplify this task a template was constructed to aid in scoring. This template is shown in Figure 1. By placing this template (which is copied onto a transparency) over the end of the filter, the filter is divided into eight equal sections, each of which can be individually scored, thus simplifying the overall rating task. Four white markings (at 0, 45, 45, and 90 degrees) were made on the rim of each of the black cigarette butt holders to serve as guides in lining up the axes of the transparency. This was done to ensure that the transparency is in the same position (and the same "pieces" are therefore scored) each time a rating is done.

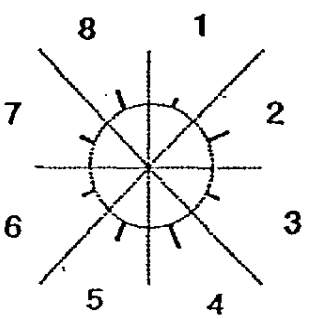

Figure 1. Scoring template used to rate the tar stains on the end of a cigarette filter.

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Procedure

The cigarette butts were once again presented to three independent raters in order of their identification numbers. The raters were given the following instructions: "Situate the cigarette butt so that the ID number appears at the bottom of the holder. Place the transparency over the cigarette butt in such a way that the axes are aligned with the white markings on the cigarette holder. This will divide the end of the cigarette butt into eight equal "pieces". For each of the eight "pieces" (numbered 1 through 8) indicate the percentage of tar stain touching the outside edge of the filter: 0%, 25%, 50%, 75%, or 100%."

Each of the three raters scored the entire set of butts twice. They scored the exterior stain pattern only. To facilitate the process of scoring each butt and recording the data, each rater verbally reported to the investigator their scores for each of the eight individual "pieces" of each filter. The investigator then directly entered the data into the computer as proportions (i.e., 0, .25, .50, .75, or 1.0).

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Data Analyses

The total proportion of the filter with tar stain reaching to the outside edge was calculated for each cigarette butt by averaging the scores for each of the eight individual "pieces" of the filter. Since each of the raters scored the entire set of butts twice, the two means scores for each butt for each rater were averaged to come up with one score for each butt for each rater. It is these values that are used to calculate the inter-rater reliability coefficients reported below. A final tar stain score for each cigarette butt was calculated by averaging the mean scores of each of the three raters.

Results

Tables 9 and 10 show the inter-rater and intra-rater reliability coefficients for the tar stain scores, respectively.

Table 9. Inter-rater reliability of tar stain scores

	Reliability Coefficients (All Raters, Single Rater)
Study 1 Butts (N=111)	.941, .841
Study 2 Butts (N=91)	.969, .912
Now® (N=44)	.967, .908
Marlboro Light® (N=46)	.965, .901

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Table 10. Intra-rater reliability of tar stain scores (all ratings, single rating, respectively)

	Rater #1	Rater #2	Rater #3
Study 1 Butts (N=111)	.925, .860	.962, .927	.944, .894
Study 2 Butts (N=91)	.926, .863	.930, .870	.959, .922
Now® (N=44)	.959, .920	.908, .832	.953, .910
Marlboro Light® (N=46)	.888, .798	.931, .871	.953, .910

The mean tar stains scores for cigarette butts from both Studies 1 and 2 are shown in Table 11.

Table 11. Mean tar stain score‡± standard deviation by study, brand and vent blocking manipulation (minimum and maximum values are in parentheses)

	Unblocked	Finger Blocked	50% Tape Blocked	LipBlocked
Study 1 Butts (N=111)	0.15 ± 0.09^a (0.03,0.46)	0.47 ± 0.21^b (0.15,0.83)	0.46 ± 0.11^b (0.24,0.72)	0.91 ± 0.14^c (0.44,1.00)
Study 2 Butts				
Now® (N=45)	0.03 ± 0.05^a (0.00,0.20)	0.35 ± 0.19^b (0.05,0.69)		
Marlboro Light® (N=46)	0.20 ± 0.17^a (0.02,0.75)	0.47 ± 0.22^b (0.22,0.99)		

‡ Mean proportions in the same row that do not share superscripts differ at $p<.0001$ by Bonferroni method of multiple comparisons

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Given the considerable overlap of tar stain scores for cigarettes with unblocked and blocked filter vents, it is necessary to determine the score, or range of scores that best discriminates between the tar stains of unblocked and blocked cigarette butts. That is, beyond what score should a cigarette be considered to have been "blocked"; or stated another way, below what score should a cigarette be considered to have been "unblocked"? Tables 12 through 14 show separately for cigarette butts from Study 1 and Study 2 the percentage correct, sensitivity and specificity values of the technique at various selected cut-off points. A cut-off value of .15, for example, indicates that all butts with tar stain scores less than .15 are considered unblocked, while all butts with tar stain scores greater than or equal to .15 are considered blocked.

Table 12. Percent correct, sensitivity, and specificity estimates at various selected cut-off points for cigarette butts from Study 1

"Cut-Off" Value	Percent Correct	Sensitivity	Specificity
<.15	90%	99%	63%
<.20	90%	93%	81%
<.21 thru <.23	91%	93%	85%
<.24	90%	92%	85%
<.25	90%	90%	89%
<.30	89%	87%	93%
<.35	86%	83%	96%
<.40	84%	80%	96%

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Table 13. Percent correct, sensitivity, and specificity estimates at various selected cut-off points for cigarette butts from Study 2: Marlboro Lights® only

"Cut-Off" Value	Percent Correct	Sensitivity	Specificity
<.15	70%	100%	39%
<.20 thru < .22	85%	100%	70%
<.23 thru <.24	81%	91%	0%
<.25	78%	87%	70%
<.30	78%	74%	83%
<.25 thru <.40	67%	48%	87%

Table 14. Percent correct, sensitivity, and specificity estimates at various selected cut-off points for cigarette butts from Study 2: Nows® only

"Cut-Off" Value	Percent Correct	Sensitivity	Specificity
<.01	80%	100%	61%
<.02	82%	100%	65%
<.03	85%	100%	70%
<.04 thru < .05	91%	100%	83%
<.06 thru < .07	88%	91%	87%
<.08 thru <.09	91%	91%	91%
<.10 thru < .14	89%	86%	91%
<.15 thru <.17	91%	86%	96%
<.18 thru < .19	89%	82%	96%
<.20	87%	77%	96%
<.25	84%	68%	100%
<.30	75%	50%	100%

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Discussion

The results of this study indicate that scoring tar stains quantitatively, based on the proportion of the filter with stain reaching to the outside edge, rather than qualitatively, based on the specific pattern of the stain, produces reliable results, both across raters and for the same rater over time. For each of the three sets of cigarette butts examined (i.e., two sets of Marlboro Lights® and one set of Nows®), the mean tar stain score was significantly lower for cigarettes with unblocked filter vents than for cigarettes in which some vent blocking had occurred (i.e., by either lips, fingers or tape), suggesting that this is a valid technique as well.

There was, however, considerable overlap in the distribution of scores, with some "unblocked" cigarettes having relatively high stain scores and some "blocked" cigarettes having relatively low stain scores. For this reason, analyses were done to determine the sensitivity and specificity of the technique at various selected "cut-off" points. As demonstrated by the results of these analyses, a trade-off exists between achieving high sensitivity and high specificity. At relatively low cut-off values, for example, the chances of detecting "any" vent blocking in cigarettes that have truly been blocked are very high. However, this high sensitivity is achieved at the expense of lower specificity: the probability of classifying truly unblocked cigarettes as such is much lower at this particular cut-off value. Alternatively, at relatively high cut-off values, the probability of correctly identifying truly "unblocked" cigarettes is very high (i.e., specificity is very high); however, many truly "blocked" cigarettes will be missed and incorrectly classified as "unblocked" at this high value.

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The question of which is more important, sensitivity or specificity, may be informed by previous research on the use of the stain pattern technique. For example Pillitteri and colleagues (1994) found that the stain patterns of cigarettes with filter vents completely blocked on only half of the puffs and the stain patterns of cigarettes with filter vents completely blocked on every puff were not distinguishable. Similarly, Zacny and colleagues (1986) found that blocking filter vents on just one puff could produce a spreading tar stain indicative of vent blocking. Given this inability to detect the extent of vent blocking, it appears that primary emphasis should be placed on using the technique to achieve accurate estimates of non-blocking.

With this in mind, a bias should exist toward selecting cut-off points that result in high levels of specificity and adequate levels of sensitivity. Considering the brands separately, it appears that a tar stain score of approximately .15 would serve as an appropriate cut-off for the detection of "non-blocking" for the brand Now®. For Marlboro Lights® a somewhat higher threshold score for non-blocking is necessary--.30 seems to best account for Marlboro Lights® from both Studies 1 and 2.

The necessity for different cut-off values for Nows® and Marlboro Lights® is not surprising, given the difference in percentage air dilution for these two brands. It has been shown that size of the central tar stain (i.e., the bull's eye-like stain) that appears when filter vents have not been blocked is dependent upon the degree of ventilation of the cigarette brand, so that "Light" cigarette brands, which are in general less ventilated than Ultra-Light cigarette brands would have a larger central stain when filter vents have not been blocked (Baker & Lewis, 1997). Regardless, of the degree of ventilation and the size of the

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central stain, however, cigarettes of both brands with unblocked filter vents were judged to have significantly less tar stain reaching to the outside edge of the filter than the cigarettes with blocked filter vents.

As discussed in Chapter Four, these cigarette butts were not prepared for the specific purpose of evaluating the validity of this technique. This would require rigid control over the vent blocking manipulations--control that was not necessarily present when these cigarette butts were prepared. Although an investigator was with the smokers at all times, it is possible that inadvertent blocking of vents on one or two puffs could have occurred on an "unblocked" cigarette, for example. Any such "mistakes" could possibly account for the considerable overlap in scores observed for the unblocked and blocked manipulations. For this reason, additional studies are necessary that utilize videotaped observations to ensure that the proper vent blocking manipulations are in fact achieved on every puff.

The recommended "cut-off points" were based on data from only two brands. The values obtained for the Nows®, however, cannot necessarily be applied to all Ultra-light brands. Nor can the values obtained for Marlboro Lights® be applied to all Light brands. Thresholds for detecting non-blocking may be dependent upon a brand's ventilation level, which can vary for different brands within the same tar yield category. It may be necessary to have different cut-off values for cigarette brands with different ventilation levels. This needs to be further evaluated with a wide range of cigarette brands with differing ventilation levels.

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Chapter 6

VENT BLOCKING DETECTION: STUDY 4

Introduction

The purpose of Study 4 was to evaluate, using a variety of cigarette brands, the reliability and validity of an alternative means of scoring tar stains for evidence of vent blocking.

Method

Cigarettes

As part of a study examining the effects of vent blocking on smoke exposure (to be described in Chapter 8), twelve female daily cigarette smokers smoked two cigarettes from each of four brands of cigarettes over the course of four experimental sessions: Carltons®, Nows®, Virginia Slims Ultra-Lights®, and Virginia Slims Lights®. The participants were instructed to smoke the cigarettes from each of these four brands as they wished (i.e., puff and inhalation parameters were free to vary and no restrictions were placed on the length of the cigarette butt).

For purposes of this study, participants were asked to smoke cigarettes from other brands as well. The brands were chosen to represent a range of standard tar yields and ventilation levels. In addition to the four brands just

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mentioned, half of the participants smoked two cigarettes from each of the following four brands: Merit Ultimas®, Cambridge Ultra-Lights®, Merits® and Basic Lights®. The participants were instructed to take only four puffs from cigarettes from each of these four brands. The other six participants smoked the following four brands in addition to the four original brands: Doral Ultra-lights®, GPC Ultra-Lights®, Doral Lights®, and Camel Lights®. Again, the participants were instructed to take only four puffs from cigarettes from each of these four brands. Table 15 shows both the filter ventilation levels and the standard tar, nicotine, and CO yields for each of the brands examined.

Table 15. Brands by tar, nicotine and carbon monoxide (CO) yields† and by percentage of filter ventilation

Brand*	Tar (mg)	Nicotine (mg)	CO (mg)	Percent ventilation± SEM
Carlton® 100 HP	1	0.1	1	82.5±.29
Now® 100 SP	2	0.2	3	66.3±.59
Virginia Slims UL® 100 HP	5	0.5	6	55.6±.72
Virginia Slims L® 100 HP	8	0.7	9	39.7±.46
Merit Ultima® SP	1	0.1	3	64.4±1.45
Cambridge UL® 100 SP	5	0.4	8	53.1±.38
Merit® HP	7	0.6	9	34.1±.71
Basic L® HP	10	0.7	12	11.1±.40
Doral UL® SP	4	0.4	6	56.7±.47
GPC UL® SP	6	0.5	7	47.9±.67
Doral L® SP	8	0.6	10	18.9±.59
Camel L® HP	11	0.9	13	22.3±.58

*HP=hard pack; SP=soft pack; UL=Ultra-light; L=Light; Unless designated 100, brand is king-size.
†Source: Federal Trade Commission, 1998

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Each participant generated both a "blocked" and an "unblocked" cigarette butt for each brand that was smoked. For the "unblocked" manipulation, participants were instructed to smoke the cigarettes in such a way that they did not cover the ventilation holes with their lips or fingers when taking a puff. For the "blocked" manipulation, participants were instructed to place the cigarettes as far into their mouth as necessary to cover the ventilation holes with their lips. The location of the ventilation holes was marked on each cigarette with a red pen prior to each of the experimental sessions. Each session was held in a room containing a one-way mirror through which video-taped observations of the smokers took place from an adjoining room. This was done to confirm that the proper vent blocking manipulations were in fact met. Every puff from each cigarette was scored by the investigator as being either "definitely blocked", "definitely unblocked", or "questionable".

The filters of all 192 cigarettes were later sliced approximately 9 mm above the end of the cigarette butt and fixed in a black rubber holder so that only the end of the tar-stained filter was visible. Each cigarette butt was randomly given an identification number.

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Procedure

The cigarette butts were presented to two independent raters in order of their identification numbers. As described in Chapter Five, the new scoring procedure estimates the proportion of the filter with tar stain reaching to the outside edge. To simplify this task a template was constructed to aid in scoring (see Figure 1 in Chapter Five). By placing this template (which is copied onto a transparency) over the end of the filter, the filter is divided into eight equal sections, each of which can be individually scored, thus simplifying the overall rating task. The raters were given the following instructions: "Situate the cigarette butt so that the ID number appears at the bottom of the holder. Place the transparency over the cigarette butt in such a way that the axes are aligned with the white markings on the cigarette holder. This will divide the end of the cigarette butt into eight equal "pieces". For each of the eight "pieces" (numbered 1 through 8) indicate the percentage of tar stain touching the outside edge of the filter: 0%, 25%, 50%, 75%, or 100%."

Both raters scored the entire set of cigarette butts twice. Raters were provided with a magnifying light (Underwriters Laboratories Inc.) to enhance the image. To facilitate the process of scoring each cigarette butt and recording the data, each rater verbally reported to the investigator their scores for each of the eight individual "pieces" of each filter. The investigator then directly entered the data into the computer as proportions (i.e., 0, .25, .50, .75, or 1.0).

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Data Analyses

Calculation of Tar Stain Score

The tar stain score (i.e., the total proportion of the filter with tar stain reaching to its outside edge) was calculated by averaging the scores for each of the eight individual "pieces" of the filter. Since each of the raters scored the entire set of butts twice, the two mean scores for each rater were averaged to come up with one tar stain score for each butt for each rater. It is these values that are used to calculate the inter-rater reliability coefficients reported below. A final tar stain score for each cigarette butt was calculated by averaging the mean scores of each of the two raters.

Validity of Vent Blocking Manipulation

Two types of "mistakes" were possible in the preparation of these butts: either failing to cover the vents on a "blocked" cigarette, or inadvertently covering the vents on an "unblocked" cigarette. Of the two, the latter has more serious implications for the resultant tar stain. Blocking filter vents on just one puff can produce a spreading tar stain indicative of vent blocking (Zacny et al., 1986). Therefore, it is necessary to identify any unblocked cigarette for which at least one puff was scored as "definitely blocked", in order to determine if these cigarettes have any influence on the pattern of results. Similarly, a "questionable" puff on an unblocked cigarette raises the possibility that the filter vents may have

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been covered on that puff. For this reason, it is also important to identify any unblocked cigarettes with at least one "questionable" puff.

Results

Table 16 shows separately for each brand the inter-rater reliability coefficients for the tar stain scores. These reliability estimates were calculated using ANOVA procedures as outlined by Winer (1971).

Table 16. Inter-rater reliability of tar stain scores

	Reliability Coefficients (Both Raters, Single Rater)
All brands combined (N=192)	.948, .901
Carlton® (N=24)	.926, .863
Now® (N=24)	.766, .621
Virginia Slims Ultra-lights® (N=24)	.997, .995
Virginia Slims Lights® (N=24)	.982, .964
Merit Ultima® (N=12)	.963, .928
Cambridge Ultra-lights® (N=12)	.982, .964
Doral Ultra-lights® (N=12)	.951, .906
GPC Ultra-lights® (N=12)	.954, .911
Merit® (N=12)	.956, .916
Basic Lights® (N=12)	.964, .931
Doral Lights® (N=12)	.966, .935
Camel Lights® (N=12)	.980, .962

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The mean tar stain scores for each brand under each vent blocking manipulation are shown in Table 17. For every brand the proportion of tar stain reaching to the outside edge of the filter was judged to be significantly greater for cigarettes with blocked filter vents than for cigarettes with unblocked filter vents ($p<.0001$ for all brands).

Table 17. Mean tar stain score± standard deviation by brand and vent blocking manipulation (minimum and maximum values in parentheses)

	Unblocked	Blocked
All brands combined (N=192)	0.15±0.16 (0.00-0.59)	0.91±0.15 (0.25-1.00)
Carlton® (N=24)	0.13±0.16 (0.00-0.54)	0.84±0.24 (0.25-1.00)
Now® (N=24)	0.27±0.15 (0.01-0.52)	0.88±0.21 (0.32-1.00)
Virginia Slims Ultra-lights® (N=24)	0.05±.003 (0.00, 0.09)	0.98±0.04 (0.88, 1.00)
Virginia Slims Lights® (N=24)	0.13±0.09 (0.02-0.38)	0.93±0.12 (0.63-1.00)
Merit Ultima® (N=12)	0.00±0.01 (0.00-0.02)	0.83±0.10 (0.70-1.00)
Cambridge Ultra-lights® (N=12)	0.01±0.02 (0.00-0.05)	0.86±0.18 (0.56-1.00)
Doral Ultra-lights® (N=12)	0.11±.06 (0.05-0.22)	0.90±0.13 (0.65-0.98)
GPC Ultra-lights® (N=12)	0.11±0.10 (0.02-0.27)	0.94±0.10 (0.50-1.00)
Merit® (N=12)	0.05±0.03 (0.02-0.07)	0.90±0.19 (0.52-1.00)
Basic Lights® (N=12)	0.25±0.12 (0.14-0.48)	0.94±0.09 (0.77-1.00)
Doral Lights® (N=12)	0.54±.03 (0.51-0.59)	0.90±0.02 (0.95-1.00)
Camel Lights® (N=12)	0.14±0.06 (0.06-0.23)	0.93±0.17 (0.59-1.00)

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None of the 81 "unblocked" cigarettes had any puffs scored as being "definitely blocked". However, 16 of these cigarettes did have at least one puff scored as being "questionable", so that it could not be determined for certain that the filter vents were in fact not blocked on every puff. Questionable ratings were usually given due to an unclear video image, participants' fingers obstructing the view of the filter vents, or participants' lips being positioned almost exactly on the line marking the location of the vents. Excluding four questionable cases reduced the mean tar stain score for Carltons® from 0.13 to 0.10. The maximum tar stain score for this brand was reduced from 0.54 to 0.22. The mean score for unblocked Nows® remained essentially the same when three questionable cases were removed, but the maximum score was reduced from 0.52 to 0.46. Questionable cases were also identified for Basic Lights® (n=1), Merits® (n=1), Doral Ultra-lights® (n=1), Cambridge Ultra-lights® (n=1), Merit Ultimas® (n=2), Virginia Slims Lights® (n=1), and Virginia Slims Ultra-lights® (n=2). Excluding these cases, however, did not affect either the mean tar stain score or the minimum and maximum scores for these brands.

Figures 2 through 13 show the distribution of tar stain scores by vent blocking manipulation for each brand. Those score categories containing unblocked cigarettes with at least one questionable puff are indicated by an asterisk at the top of the column, with the number of asterisks indicating the number of "questionable" cigarettes in that category. For 12 of the 14 brands there was no overlap in scores for the two vent blocking manipulations.

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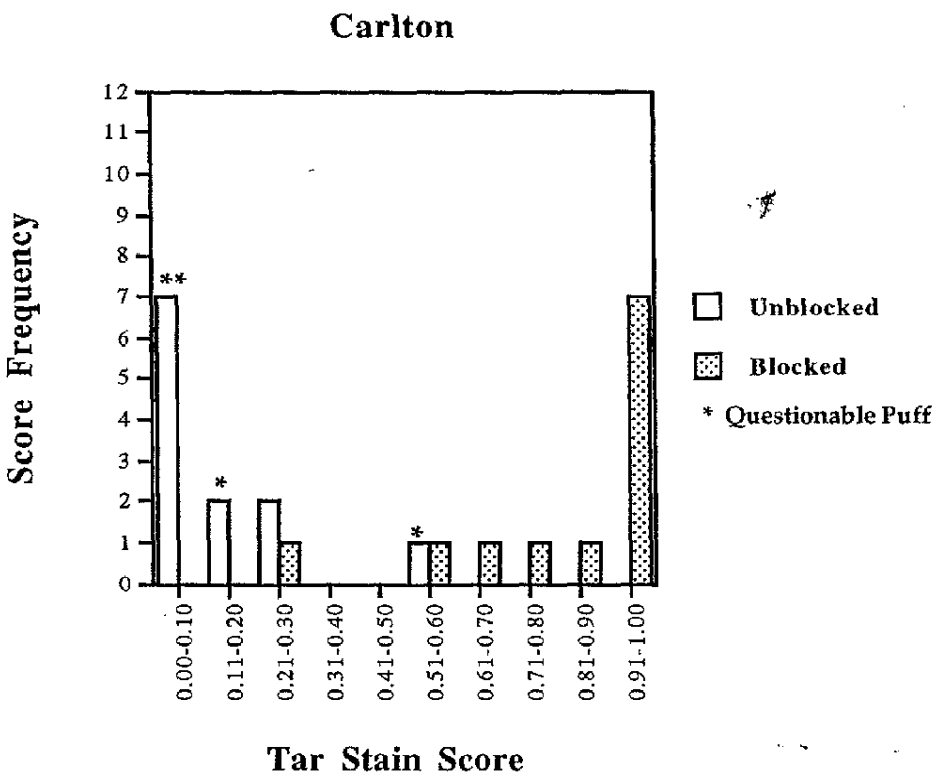

Figure 2. Distribution of tar stain scores by vent blocking manipulation for Carltons®.

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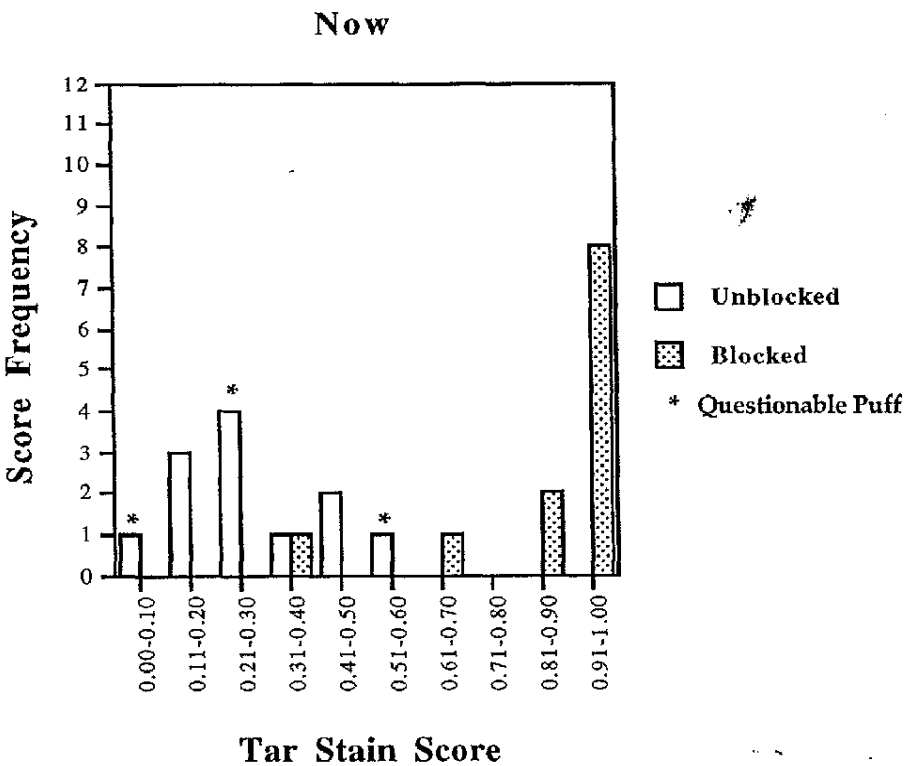

Figure 3. Distribution of tar stain scores by vent blocking manipulation for Nows®.

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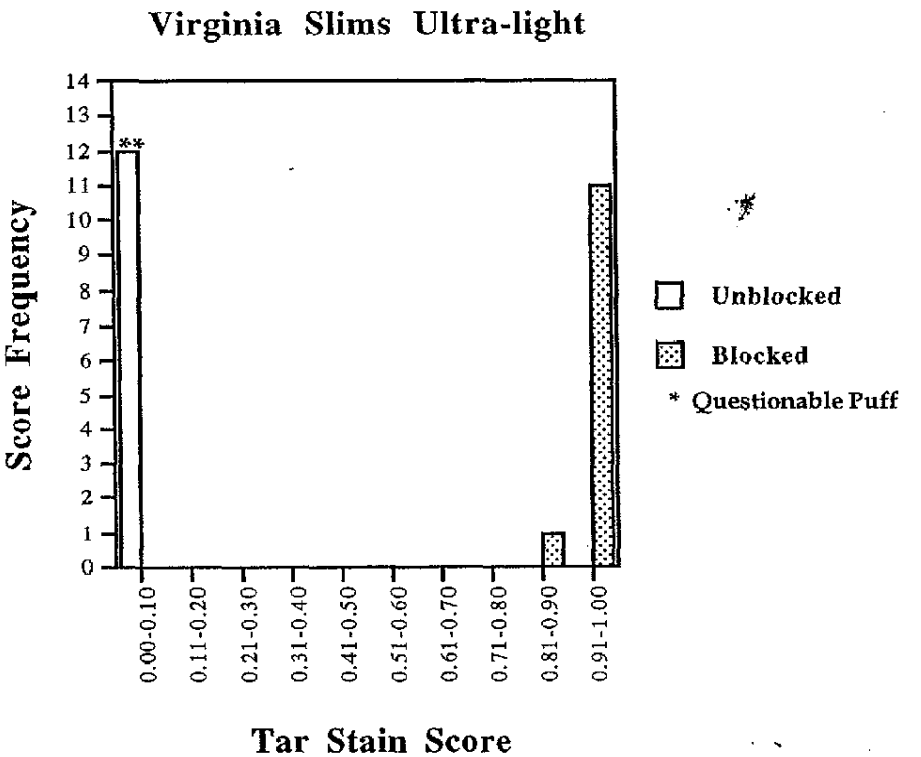

Figure 4. Distribution of tar stain scores by vent blocking manipulation for Virginia Slims Ultra-lights®.

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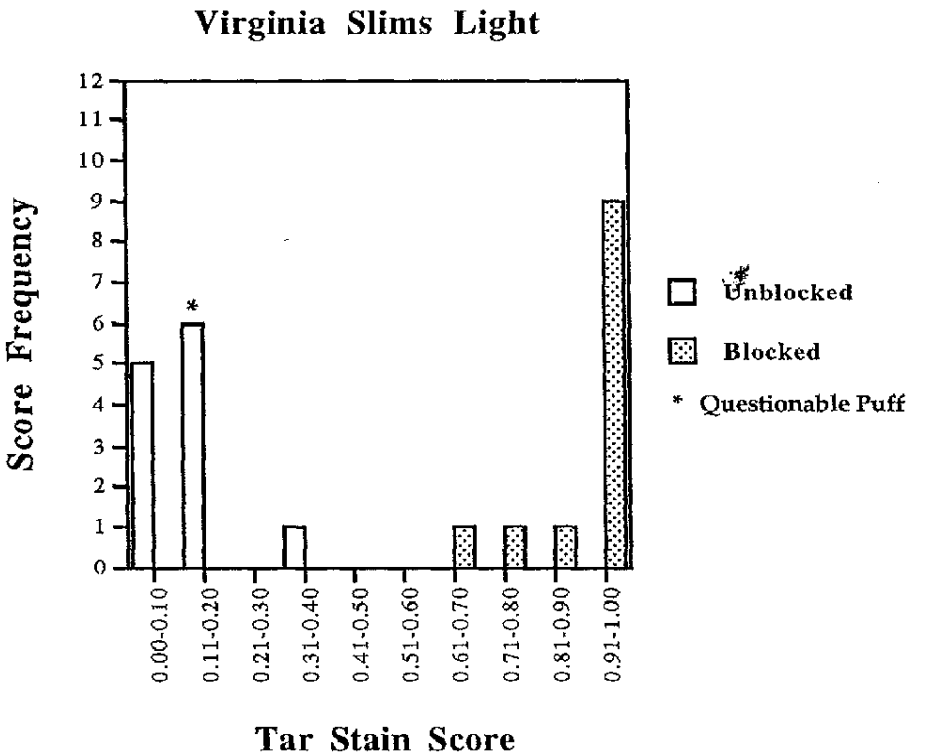

Figure 5. Distribution of tar stain scores by vent blocking manipulation for Virginia Slims Lights®.

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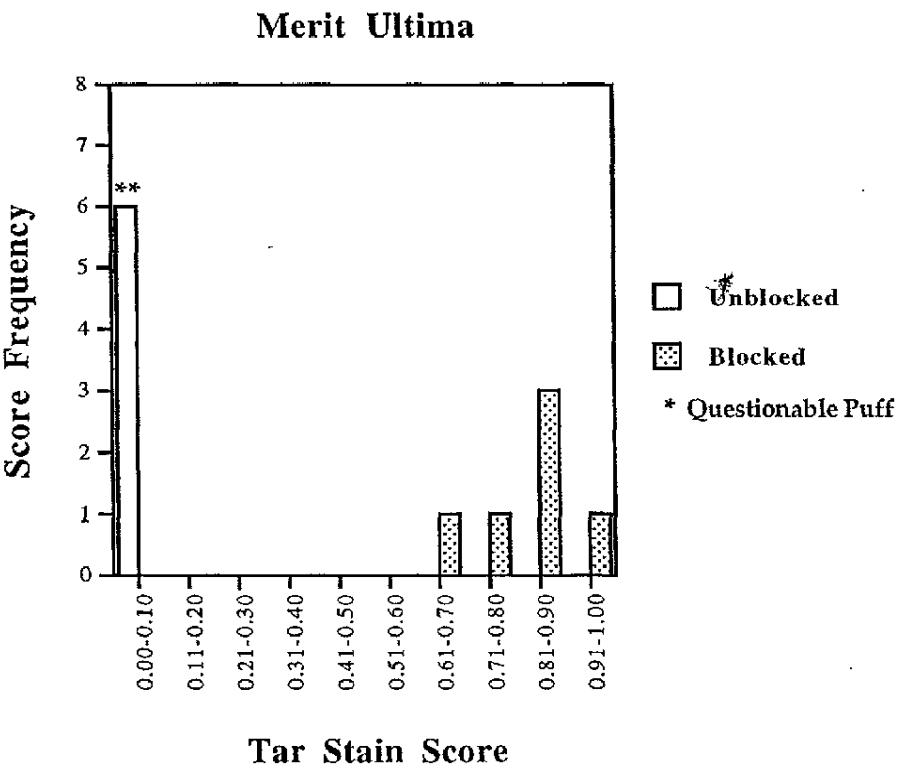

Figure 6. Distribution of tar stain scores by vent blocking manipulation for Merit Ultimas®.

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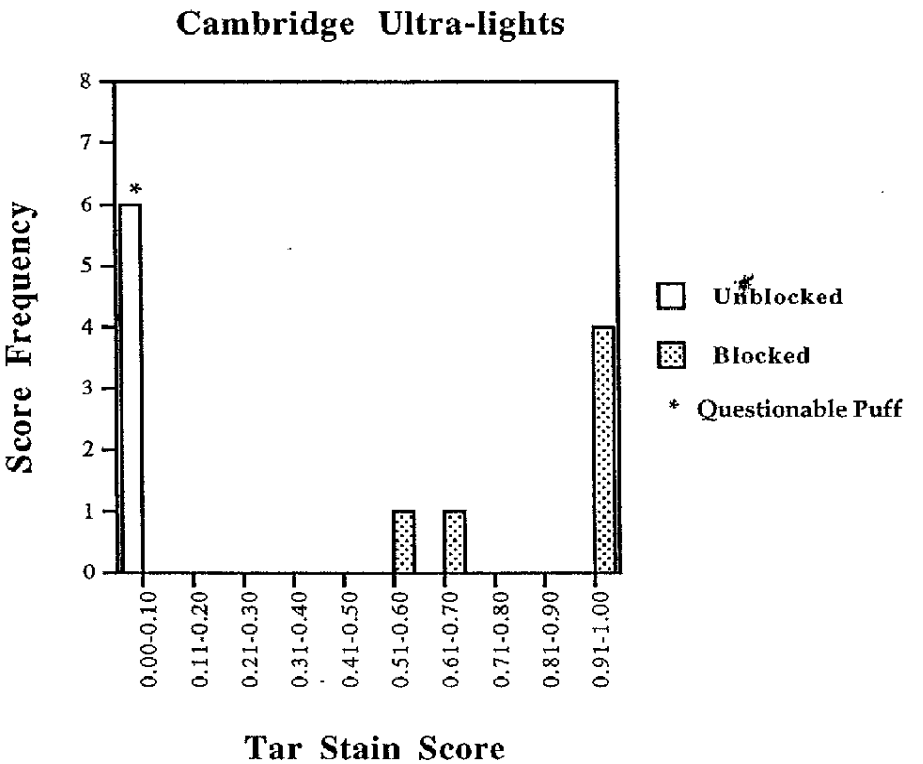

Figure 7. Distribution of tar stain scores by vent blocking manipulation for Cambridge Ultra-lights®.

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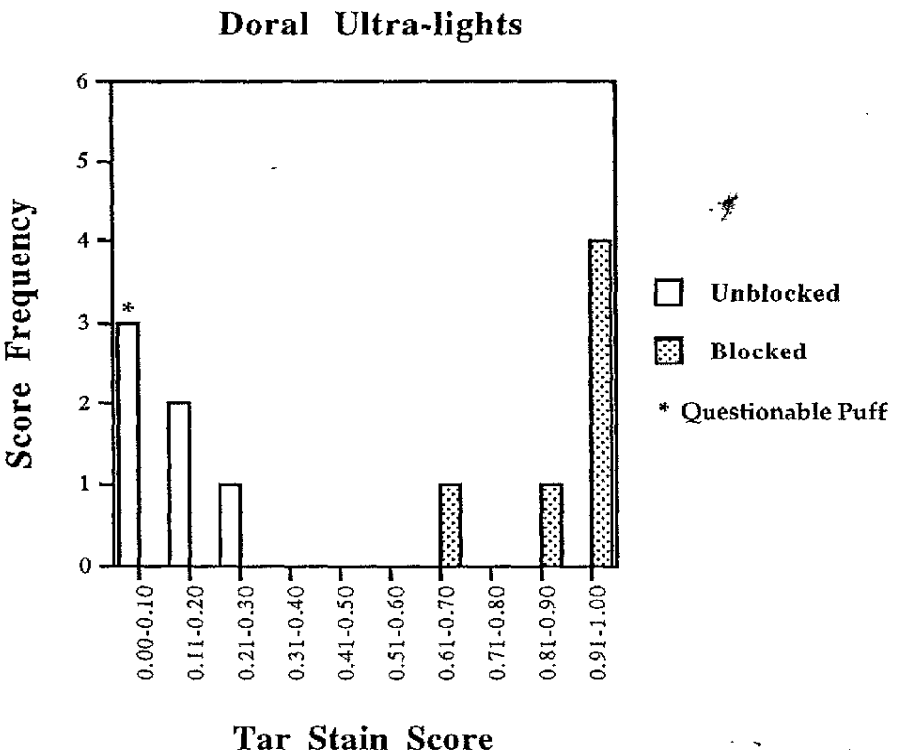

Figure 8. Distribution of tar stain scores by vent blocking manipulation for Doral Ultra-lights®.

Source: https://www.industrydocuments.ucsf.edu/docs/lmcl0001

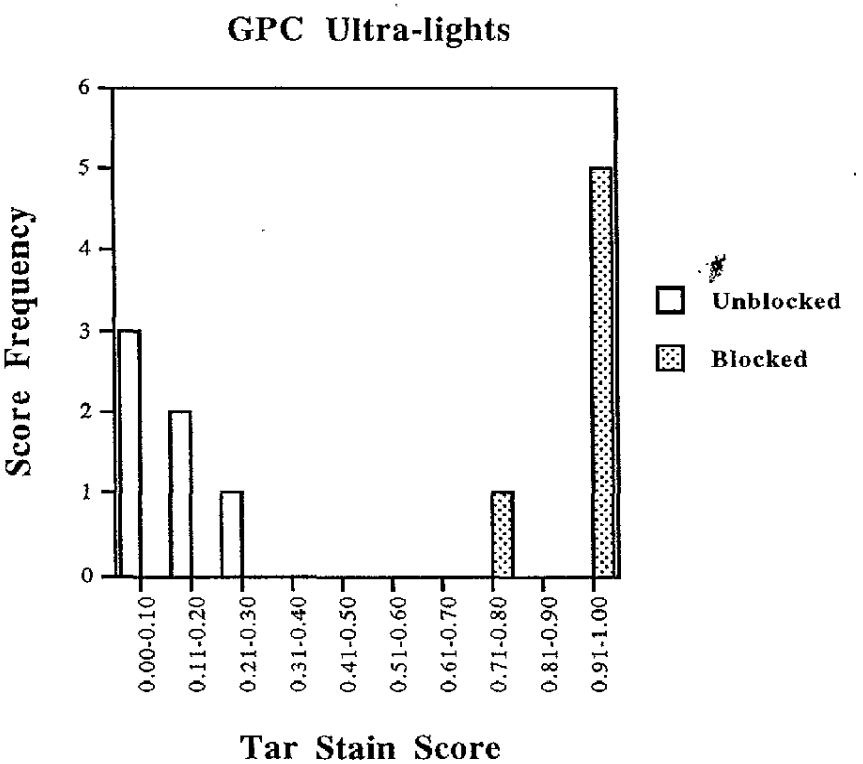

Figure 9. Distribution of tar stain scores by vent blocking manipulation for GPC Ultra-lights®.

Source: https://www.industrydocuments.ucsf.edu/docs/lmcl0001

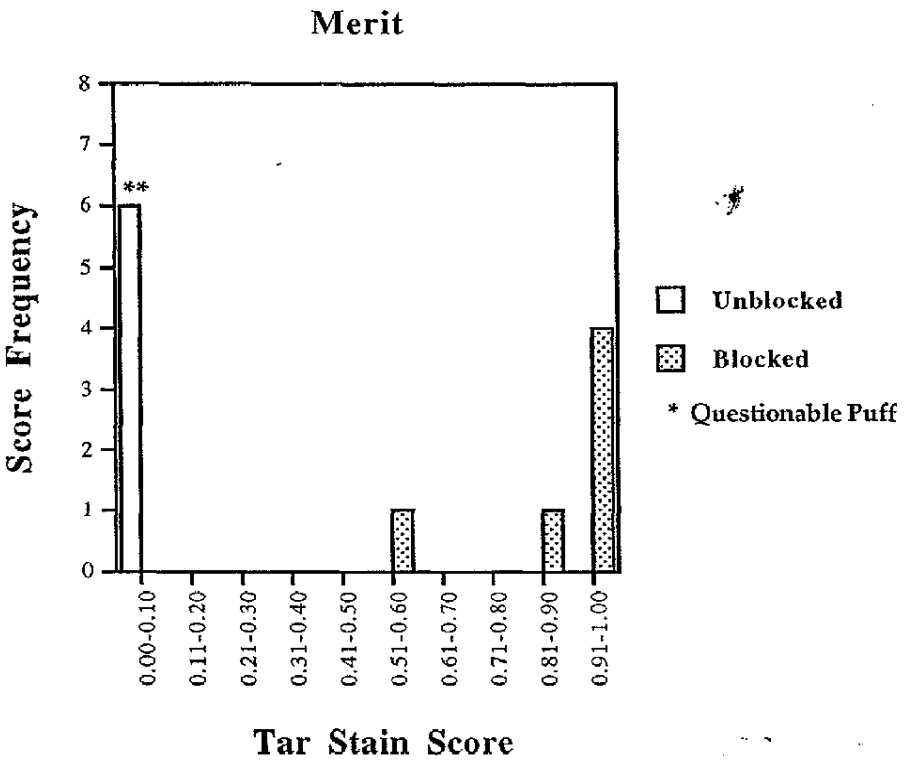

Figure 10. Distribution of tar stain scores by vent blocking manipulation for Merits®.

Source: https://www.industrydocuments.ucsf.edu/docs/lmcl0001

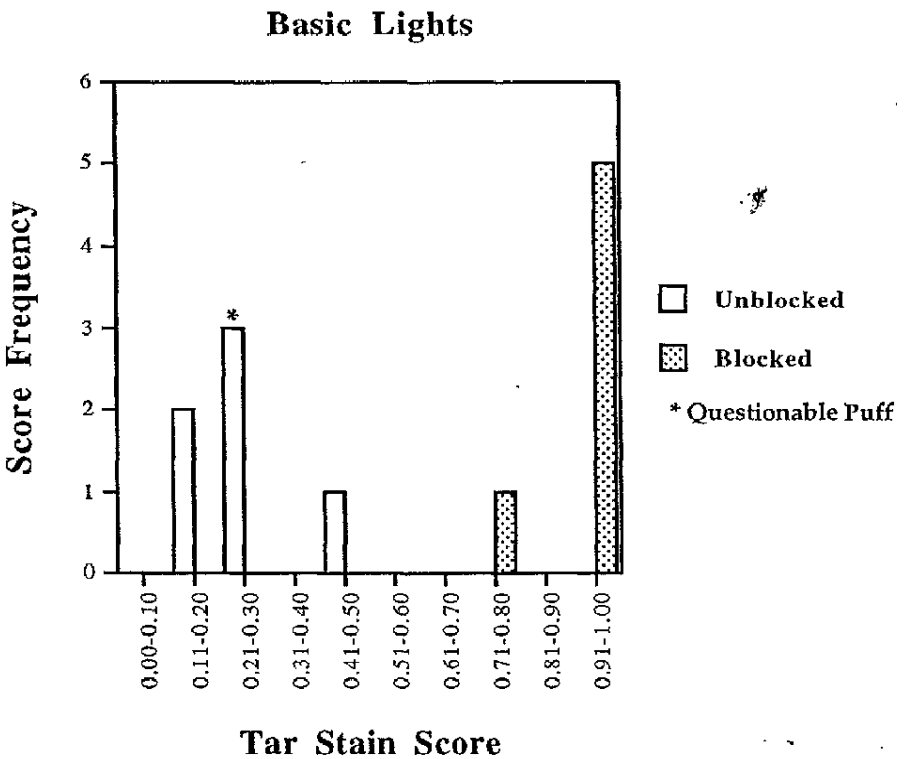

Figure 11. Distribution of tar stain scores by vent blocking manipulation for Basic Lights®.

Source: https://www.industrydocuments.ucsf.edu/docs/lmcl0001

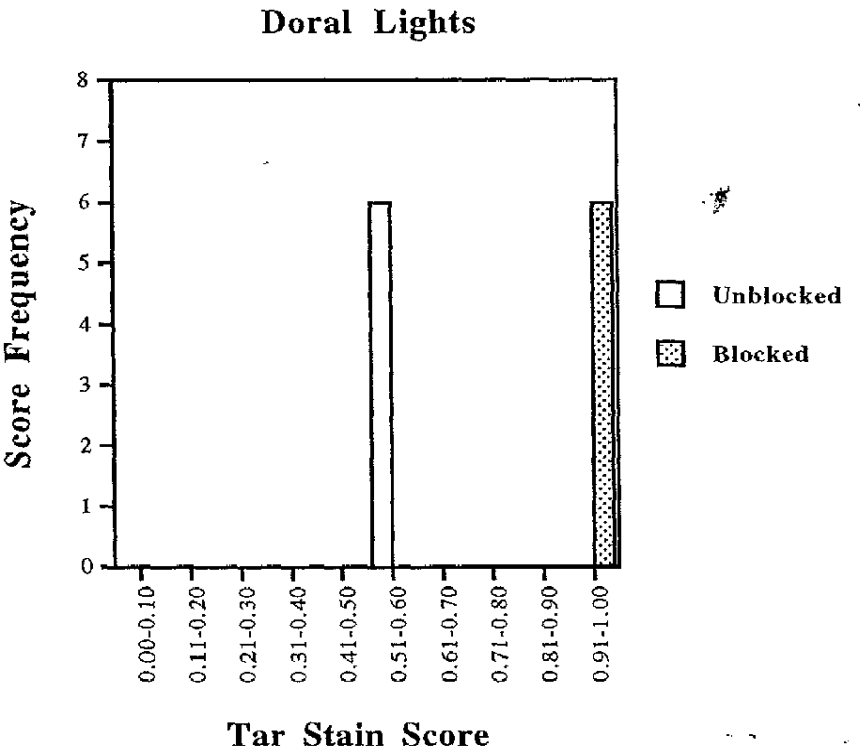

Figure 12. Distribution of tar stain scores by vent blocking manipulation for Doral Lights®.

Source: https://www.industrydocuments.ucsf.edu/docs/lmcl0001

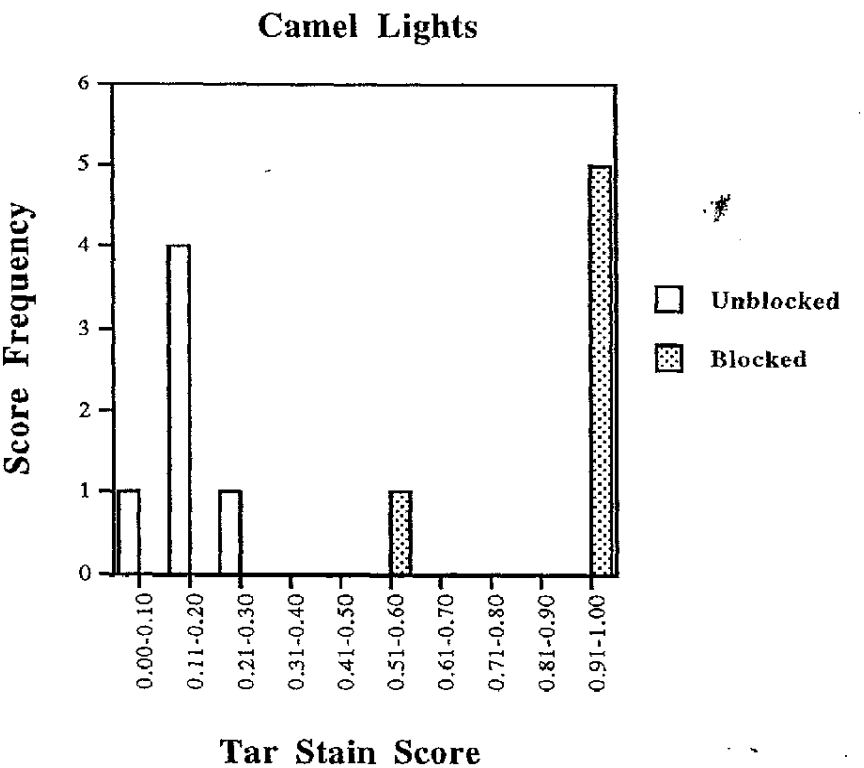

Figure 13. Distribution of tar stain scores by vent blocking manipulation for Camel Lights®.

Source: https://www.industrydocuments.ucsf.edu/docs/lmcl0001

Based on the data shown in the figures, it is clear that for the majority of brands there is a range of tar stain scores indicative of non-blocking, and another distinct range of scores indicative of blocking. It would be useful, however, to come up with a general score, or range of scores, that best discriminates between tar stains of unblocked cigarettes and tar stains of blocked cigarettes for all brands. Table 18 shows how the percentage correct, sensitivity (true-positive rate) and specificity (true-negative rate) values change at different "cut-off" points (i.e., points below which cigarettes are classified as unblocked and above which are classified as blocked). These values have been calculated with the 16 questionable cases excluded, so that the total number of cigarettes is reduced to 176.

Table 18. Percent correct, sensitivity and specificity estimates at various selected cut-off points for all brands combined

"Cut-Off" Value	Percent Correct	Sensitivity	Specificity
<0.15	84%	100%	64%
<0.20	88%	100%	74%
<0.25	92%	100%	83%
<0.30	93%	99%	86%
<0.35	93%	98%	86%
<0.40	94%	98%	89%
<0.45	94%	98%	90%
<0.50	95%	98%	93%
<0.55	97%	96%	98%
<0.60	97%	94%	100%

Source: https://www.industrydocuments.ucsf.edu/docs/lmcl0001

Discussion

The results of this study are consistent with those of the study described in Chapter Five in finding that this alternative method of scoring tar stains for evidence of vent blocking produces consistent results, both within and between raters. While the earlier study demonstrated the reliability of this technique with only two cigarette brands, this study showed that the technique can be reliably used with a variety of other ventilated-filter brands as well.

Not only were the tar stain scores reliable, but they appear to be valid indicators of the occurrence (and non-occurrence) of vent blocking. For each of the twelve brands examined in this study, the mean score for cigarettes with blocked filter vents was significantly higher than the mean score for cigarettes with unblocked filter vents. Considering the distribution of scores, for the majority of brands there was no overlap between scores for unblocked cigarettes and scores for blocked cigarettes. In fact for several of the brands, the gap between unblocked scores and blocked scores was quite large. However, this study examined the technique's effectiveness in discriminating between cigarettes in which no blocking had occurred and cigarettes in which extreme blocking had occurred; that is, the complete blockade of the filter vents on each and every puff. Had the cigarettes been only partially blocked, as with fingers, or blocked on only one or two puffs, there may have been considerably more overlap in the unblocked and blocked scores.

Previous research has shown that tar stains cannot effectively be used to discriminate among degrees of vent blocking (Pillitteri, Morse, & Kozlowski, 1994). For example, two cigarettes may have identical stain scores of 0.90.

Source: https://www.industrydocuments.ucsf.edu/docs/lmcl0001

However, vent blocking may have occurred on ten out of ten puffs for one cigarette, but on only one out of ten puffs for the other. Given this limitation, primary emphasis should be placed on using the technique to detect instances when filter vents have not been blocked. It is therefore necessary to determine the critical value or range of values below which tar stain scores are most likely to be indicative of no blocking having occurred. The results of this study indicate that these critical scores are not necessarily the same for all ventilated-filter brands. For example, for Virginia Slims Ultra-lights, tar stain scores less than or equal to 0.10 are most likely to indicate that the filter vents on that cigarette have not been blocked. The critical value for Virginia Slims Lights, however appears to be somewhat higher: tar stain scores of 0.40 or less for this brand are indicative of unblocked filter vents.

Given this variation, the most precise estimates will be obtained if the criteria for non-blocking are applied on a brand by brand basis. However, this study examined only a small portion of the total number of ventilated-filter brands on the market. Additional studies are necessary to determine the critical tar stain values for other brands as well. It is important that such studies utilize videotaped observation, given the possibility of "mistakes" in the preparation of the cigarette butts, as shown by this and other studies.

Researchers, however, may not always have specific brand information for the cigarettes they wish to measure. In such instances, it appears that a tar stain score of approximately 0.60 can be used as a generic cut-off value for detecting non-blocking. At this value, 100% of the truly unblocked cigarettes in this study were classified as such, with only a slight decline in the sensitivity in detecting truly blocked cigarettes.

Source: https://www.industrydocuments.ucsf.edu/docs/lmcl0001

For several of the brands the maximum tar stain score obtained for cigarettes with unblocked filter vents was relatively high, even when the cigarettes with questionable puffs were excluded. For example, the scores for unblocked Doral Lights® were consistently in the 0.51-0.60 range. However, this brand did not exhibit the characteristic bull's eye stain pattern normally observed when filter vents are not blocked; rather, an asterisk-like pattern was observed for each of the six unblocked cigarettes of this brand. Using this new method of scoring, however, tar stains could still be used to reliably distinguish between cigarettes with blocked and unblocked filter vents. This speaks to the advantage of rating tar stains quantitatively based on the degree of spread across the filter, rather than qualitatively based on the specific pattern of the stain.

Several of the unblocked Nows® also had relatively high stain scores, ranging between 0.40 and 0.60. It appears that these high values may have been due to discrepancies in scoring between the two raters for these cigarettes. While one rater consistently gave these cigarettes relatively low stain scores, the other rater gave these same cigarettes relatively high stain scores. This discrepancy in scoring is reflected in the relatively low inter-rater reliability coefficients obtained for this brand. Averaging these extreme scores resulted in overall scores usually falling between 0.40-0.50. Inspection of the tar stains of several of these cigarettes revealed a similar pattern: although there did appear to be some staining throughout the entire filter, the staining was not uniform in color. Instead, there was a clearly distinguishable dark central stain surrounded by an area of lighter stain. In future studies raters should be instructed to indicate the percentage of the central stain that touches the outside edge of the filter, in order to avoid confusion related to disparities in the color of the stain.

Source: https://www.industrydocuments.ucsf.edu/docs/lmcl0001